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NATIONAL DAM SAFETY PROGRAM. KINNIPPI LAKE DAM (MO 30406), MISS--ETC(U)
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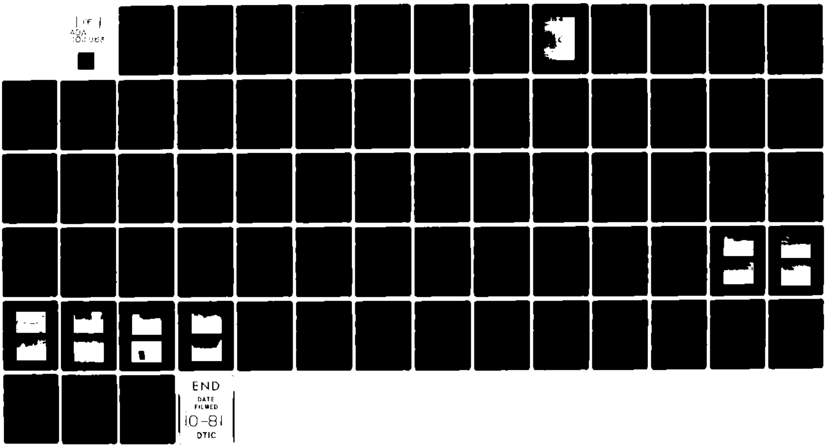

LEVEL II

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

AD A104963

KINNIPPI LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO. 30406

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY 1981

UNCLASSIFIED

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Kinnippi Lake Dam (Mo. 30406) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Kinnippi Lake Dam (Mo. 30406).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 14 JUL 1981 — Date

APPROVED BY: SIGNED — Colonel, CE, Commanding — 15 JUL 1981 — Date

Accession For

A

KINNIPPI LAKE DAM

JEFFERSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30406

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY

PRC CONSOER TOWNSEND, INC.

ST. LOUIS, MISSOURI

AND

PRC ENGINEERING CONSULTANTS, INC.

ENGLEWOOD, COLORADO

A JOINT VENTURE

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

JULY 1981

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Kinnippi Lake Dam, Missouri Inventory No. 30406
State Located:	Missouri
County Located:	Jefferson
Stream:	The headwaters of Dry Creek
Date of Inspection:	March 4, 1981

Assessment of General Condition

Kinnippi Lake Dam was inspected by the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture) in accordance with the U. S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Located within the estimated damage zone of four miles downstream of the dam are two dwellings, two trailers, one sewage lagoon, two buildings, one lake and dam (Mo. 30408), and two road crossings, which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Kinnippi Lake Dam is in the small size classification since it is 26.5 feet high and has a maximum reservior impoundment of 97 acre-feet.

The inspection and evaluation indicates that the spillway of Kinnippi Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Kinnippi Lake Dam being a small size dam with a high hazard potential is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping the dam. Considering the small size of the dam, the storage capacity of the reservoir and the small number of dwellings in the downstream hazard zone, one-half of the Probable Maximum Flood is considered the appropriate spillway design flood for Kinnippi Lake Dam. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. It was determined that the reservoir/spillway system can accommodate approximately 35 percent of the Probable Maximum Flood without overtopping the dam. The evaluation also indicates that the reservoir/spillway system can accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The overall condition of the dam and spillway appears to be good; however, some deficiencies were noted by the inspection team. The deficiencies included: the presence of rodent burrows on the downstream slope; the erosion observed in the inlet area of the spillway; the erosion of the upstream slope due to wave action and the lack of proper protection on the slope; the trees growing on the upstream and downstream slopes and in the spillway discharge channel; the erosion of the downstream slope adjacent to the spillway discharge channel; a need for periodical maintenance of the grass cover in the spillway channel and a lack of a maintenance schedule; and there also exists a need for periodic inspection by a qualified engineer. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.

STATE OF MISSOURI
WALTER
G. SHIFRIN
NUMBER
E-8834
REGISTERED PROFESSIONAL ENGINEER

Walter G. Shifrin, P.E.

Overview of Kinnippi Lake Dam

NATIONAL DAM SAFETY PROGRAM

KINNIPPI LAKE DAM, I.D. No. 30406

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

KINNIPPI LAKE DAM, Missouri Inv. No. 30406

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Kinnippi Lake Dam was carried out under Contract DACW 43-81-C-0063 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of PRC Consoer Townsend, Inc. of St. Louis, Missouri, and PRC Engineering Consultants, Inc. of Englewood, Colorado, (A Joint Venture).

b. Purpose of Inspection

The visual inspection of Kinnippi Lake Dam was made on March 4, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site and of the structural adequacy

of the various project features, and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the north abutment or side, and right to the south abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase I Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection and conversations with Mrs. Reba Hubbard, co-owner of the dam. No design or "as-built" drawings for the dam or appurtenant structures were available.

The dam is a homogeneous, rolled, earthfill structure with a core trench excavated to the foundation bedrock, according to Mrs. Hubbard. The alignment of the dam is straight between earth abutments. A plan and elevation of the dam are shown on Plate 3 and

Photos 1 through 3 show views of the dam. The top of the dam has a length of 585 feet and an assumed minimum elevation of 800 feet above mean sea level (M.S.L.). From the left abutment, the top of dam slopes downward to a point 120 feet to the right of the abutment with a drop in elevation of 1.7 feet. The top of dam was surveyed to be level for the next 200 feet to a point 265 feet to the left of the right abutment. From this point, the top of dam slopes upward with a rise in elevation of 0.9 feet to a point 85 feet to the left of the right abutment. The remaining 85 feet of the top of dam was surveyed to be level. The embankment has a top width of 12 feet and a maximum structural height of 26.5 feet. The downstream slope was measured to be 1 vertical to 4 horizontal (1V to 4H). The upstream slope varied from 1V to 4H from the top of the dam to the normal water surface level to 1V to 6H from the normal water surface level to the water surface level on the day of the inspection.

There is only one spillway at the damsite which consists of an earth-lined channel cut into the right abutment approximately 55 feet from the right end of the dam. The inlet to the spillway is trapezoidal in shape (see Photo 6). This shape undergoes a gradual transition to a triangular configuration at the control section (see Photo 7). The control section is in line with the axis of the dam and has a crest elevation of 796.1 feet above M.S.L. The cross section of the control section has a top width of 27 feet and side slopes of 1V to 3H and 1V to 2.5H on the left and the right, respectively. Two wooden poles form the remnants of a foot bridge spanning the top of the spillway at the control section (see Photo 7). The spillway channel is grass-lined up to and through the control section. Beyond the control section the spillway discharge channel is fairly level and the bottom widens yielding a trapezoidal shape. The channel is lined with a combination of earth and weathered bedrock. At this point, the channel also begins to curve toward the dam embankment. As the discharge channel proceeds down the right abutment, the shape varies between triangular and trapezoidal and the alignment meanders slightly (see Photo 8). Flow from the discharge channel enters a fairly level grass covered area just

downstream of the toe of the dam near the maximum section where the downstream channel is encountered.

No low-level outlet or outlet works were provided for for this dam.

b. Location

Kinnippi Lake Dam is located in Jefferson County in the State of Missouri at the headwaters of Dry Creek. The location of the dam on the 7.5 minute series of the U.S. Geological Survey maps is found in the southeast quadrant of Section 6 of Township 39 North, Range 4 East, of the Fletcher, Missouri Quadrangle Sheet (Advance Print, see Plate 2). The dam is also located approximately four miles west of De Soto and seven miles southwest of Hillsboro (see Plate 1).

c. Size Classification

The reservoir impoundment of Kinnippi Lake Dam is less than 1,000 acre-feet but more than 50 acre-feet, which would classify it as a "small" size dam. The maximum height of the dam is less than 40 feet and greater than 25 feet, which also classifies it as a "small" size dam. The size classification is determined by either the storage or height, whichever gives the larger size category. Therefore, the size classification is determined to fall within the "small" category, according to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineer.

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. From a visual inspection of the downstream area, our findings concur with this classification. Located within the estimated damage zone, which extends approximately four miles downstream of the dam, are at least two dwellings, two trailers, one sewage lagoon, two buildings, one lake and dam (Mo. 30408), and two road crossings (see Photo 12).

e. Ownership

Kinnippi Lake Dam is owned privately by a partnership. The partners are Mrs. Reba Hubbard and Mr. and Mrs. Harold Donald. The mailing addresses are Mrs. Reba Hubbard, 803 West Kelly Street, De Soto, Missouri, 63020 and Mr. and Mrs. Harold Donald, Star Route, Box 74, De Soto, Missouri, 63020.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake. The lake and dam are part of a subdivision development.

g. Design and Construction History

Kinnippi Lake Dam was built in 1960 by Mr. Howard Hubbard, the deceased husband of Mrs. Hubbard.

Mr. Hubbard sent foundation soil samples to be analyzed to the Geological Survey in Rolla, Missouri, before construction of the dam began. The soil analyses indicated the site was suitable for a damsite, according to Mrs. Hubbard. The results of the analyses were not available for this report.

The dam was built without specifications or drawings. A core trench was excavated to sound bedrock along the dam axis, according to Mrs. Hubbard. Mrs. Hubbard also stated that embankment fill was compacted by a sheepsfoot roller.

No modifications have been made to the dam or spillway since their original construction, according to Mrs. Hubbard.

h. Normal Operational Procedures

The dam is used to impound water for recreational use. Normal procedure is to allow the lake to remain as full as possible with the water level below the elevation of the spillway crest being controlled by rainfall, runoff, and evaporation. The lake is also fed by three natural springs, according to Mrs. Hubbard.

1.3 Pertinent Data

a. Drainage Area (square miles): 0.14

b. Discharge at Damsite

Estimated experienced maximum flood (cfs): 8

Estimated ungated spillway capacity with reservoir at top of dam elevation (cfs): 279

c. Elevation (Feet above MSL)

Top of dam (minimum): . . . . 800.0 (assumed)*

Spillway crest: 796.1

Normal Pool: 796.1

Maximum Experienced Pool: 797.1

Observed Pool: 794.4

d. Reservoir

Length of pool with water surface at top of dam elevation (feet): 1300

e. Storage (Acre-Feet)

Top of dam (minimum): 97

Spillway crest: 64

Normal Pool: 64

Maximum Experienced Pool: 71

Observed Pool: 56

f. Reservoir Surfaces (Acres)

Top of dam (minimum): 10.0

Spillway crest: 7.0

Normal Pool: 7.0

Maximum Experienced Pool: 7.5

Observed Pool: 6.0

g. Dam

Type:	Rolled, Earthfill
Length:	585 feet
Structural Height:	26.5 feet
Hydraulic Height**:	26.5 feet
Top width:	12 feet
Side slopes:	
Downstream	1V to 4H (measured)
Upstream	Varied from 1V to 4H (from the top of dam to the normal water surface elevation) to 1V to 6H (below the normal water surface elevation to the elevation of the water surface on the day of the inspection)
Zoning:	Homogeneous
Impervious core:	N.A.
Cutoff:	A trench excavated to bedrock, according Mrs. Hubbard
Grout curtain:	None
Volume:	45,000 cu. yds. (Estimated)

h. Diversion and Regulating Tunnel. . . . . None

i. Spillway

Type:	Triangular-shaped, earthcut channel, uncontrolled.
Location:	Right abutment
Length of crest:	N.A.
Top width:	27 feet
Depth:	4.8 feet
Crest Elevation (feet above MSL):	796.1

j. Regulating Outlets. . . None

* No exact elevation is known for the top of dam, therefore, an elevation was estimated from the Fletcher, Missouri, U.S.G.S. Quadrangle sheet, Advance Print. This estimated elevation is referred to as an assumed elevation. All other elevations were determined from the assumed top of dam elevation and field measurements.

** The hydraulic height of the dam is the vertical distance from the lowest point on the downstream toe to the top of dam or the maximum water surface, if below the top of dam.

SECTION 2: ENGINEERING DATA

2.1 Design

No design drawings, design calculations, or specifications are available for this dam.

2.2 Construction

The dam was built by Mr. Howard Hubbard of DeSoto, Missouri, in 1960. No documented data are available concerning the construction of the dam and spillway, other than the construction history given in Section 1.2g.

2.3 Operation

No operational records are available for Kinnippi Lake Dam.

2.4 Evaluation

a. Availability

The availability of engineering data is poor and consists only of a general soils map of the State of Missouri published by the Soil Conservation Service, State Geological Maps and U.S.G.S. quandrangle sheets. No design drawings, design computations, construction data, or operation data are available.

b. Adequacy

The lack of engineering data did not allow for a definitive review and evaluation. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing and evaluating design, operation, and construction data, but is based primarily on the visual inspection, past performance history, and present condition of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

No valid engineering data pertaining to the design or construction of the dam and the spillway were available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Kinnippi Lake Dam was made on March 4, 1981. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Mark Haynes, P.E.	PRC Engineering Consultants, Inc.	Soils
Jerry Kenny	PRC Engineering Consultants, Inc.	Hydraulics and Hydrology
James Nettum, P.E.	PRC Engineering Consultants, Inc.	Civil-Structural and Mechanical
Razi Quraishi, R.P.G.	PRC Engineering Consultants, Inc.	Geology
John Lauth, P.E.	PRC Consoer Townsend, Inc.	Civil-Structural

Specific observations are discussed below.

b. Dam

The overall condition of the dam appears to be good; however, a few items of concern were observed and are described below.

The top of dam is occasionally used as an access road (see Photo 2). Access to the dam is gained from the left abutment only. Vehicular traffic across the dam has caused very little damage, with only two minor tire ruts observed. A surficial layer of gravel and a well maintained grass cover outside of the two paths created by the vehicular traffic were observed on the top of dam. The combination of the gravel and grass cover appears to provide adequate protection against erosion due to surface runoff for the top of dam. No depressions or cracks indicating a settlement of the embankment were observed. The variation in elevation across the top of dam did not appear to be due to an instability of the embankment. No significant deviation in the horizontal alignment was apparent. According to Mrs. Hubbard, the dam has never been overtopped and no evidence indicating the contrary was observed.

The upstream slope has no riprap protection. Consequently, considerable erosion due to wave action has occurred at the normal water surface level. Near vertical scarps up to two feet high were seen above the normal water surface level (see Photo 4). The portion of the slope above the wave erosion was protected against surface runoff erosion by an adequate cover of grass. No bulges, depressions or cracks indicative of any movement of the embankment or foundation were apparent. Several small to medium sized trees up to eight inches in diameter were observed on the slope (see Photos 1 and 4).

The downstream slope of the dam appears to be adequately protected from surface runoff erosion by a well maintained grass cover (see Photo 3); however, some erosion rivulets were observed on the slope near the right side of the dam. Nevertheless, the rivu-

lets appeared to have been stabilized by vegetative growth and no evidence of recent erosive action was apparent. A few, small, dish-shaped scarps were also seen in the area of the erosion rivulets; however, the scarps are grown over with vegetation, which would indicate that the partial failure of the slope in this area was in the past and the slope appears to have stabilized. Discharges through the spillway are not properly channelized away from the embankment; consequently, some erosion along the toe of the dam has occurred. No major depressions, bulges, or cracks indicative of a slope movement were apparent on the slope.

No evidence of seepage through the embankment or foundation was apparent; however, standing water was observed near the control section and in the discharge channel of the spillway, in the downstream channel just downstream of the maximum section of the dam and on the top of the dam. The source of the water appeared to be due to recent rainstorms in the area. Nevertheless, no measurable flow of water was observed.

Both abutments slope gently upward from the dam. No instabilities, seepage or erosion were observed on either abutment, except for some erosion in the discharge channel of the spillway.

According to Mrs. Hubbard, there has been some muskrat activity in the reservoir in the past; however, the muskrats are annually trapped. Rodent burrows up to six inches in diameter were observed in several areas on the downstream slope (see Photo 5). No evidence of burrowing animals was apparent on either abutment or the remaining portion of the dam.

c. Project Geology and Soils

(1) Project Geology

The damsite is located at the headwaters of Dry Creek in the Salem Plateau section of the Ozark Plateaus Physiographic Province. Deep dissection of topography by major streams is one of the important characteristics of the Salem Plateau section. There is wide distribution of dolomites and limestones in the Salem Plateau. Cuestaform topography is exhibited in this plateau section consisting of two major escarpments, namely the Crystal Escarpment and Burlington Escarpment. Deep dissection in dolomites and limestones is a major factor in the development of the three natural springs at the damsite. A major component of surface discharge of water into Kinnippi Lake is contributed by these springs.

The topography in the vicinity of the damsite is rolling to hilly with U- to V-shaped valleys. Elevations of the ground surface range from 551 feet above M.S.L. nearly 3.7 miles southwest of the damsite to 800 feet above M.S.L. at the damsite. The reservoir slopes are generally from nine- to twelve-degrees from horizontal. The reservoir slopes are stable and the reservoir appears to be watertight. The area near the damsite is covered with residual soil deposits consisting of a reddish-brown to orangey-brown, moderately plastic, silty clay with a trace of fine sand.

The regional bedrock geology beneath the residual soil deposits in the damsite area as shown on the Geologic Map of Missouri (1979) (see Plate 5) are of the Ordovician age rocks consisting of Decorah Formation, St. Peter Sandstone, Powell Dolomite, Cotter Dolomite, Roubidoux Formation, and Gasconade Dolomite; and the Cambrian age rocks consisting of Eminence Dolomite, Potosi Dolomite, and Franconia and Bonneterre Formations. The predominent bedrock underlying the residual soil deposits in the vicinity of the damsite are the Ordovician age rocks consisting of Powell Dolomite, Roubidoux Formation, Gasconade Dolomite and St. Peter Sandstone.

Outcroppings of Ordovician Powell Dolomite (light brown, fine grained, hard, thinly bedded, slightly weathered dolomite) are exposed in the discharge channel of the spillway (see Photo 10).

No faults have been identified at the damsite. The closest trace of a fault to the damsite is the Ste. Genevieve fault system nearly 1.5 miles southwest of the damsite. The Ste. Genevieve fault had its last movement in post-Pennsylvanian time. Thus, the fault has no effect on the damsite.

No boring logs or construction reports were available that would indicate foundation conditions encountered during construction. Based on the visual inspection and conversations with Mrs. Hubbard, the embankment probably rests on Ordovician Powell Dolomite bedrock with the core trench excavated to the bedrock. The earth-lined spillway was cut into the residual soils of the right abutment, which overlays the dolomite bedrock.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Description" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Union-Goss-Gasconade-Peridge in the Ozark Border Association. The soils are basically formed from loess deposits and weathered bedrock. These soils vary from a slowly permeable silty clay to moderately permeable silt loam.

Material removed from the embankment slopes was a light brown, moderately plastic, silty clay with traces of fine sand and small rock fragments. Based upon the Unified Soil Classification System, the soil would probably be classified as a CL. This is an impervious soil type, which generally has the following characteristics: a coefficient of permeability less than one foot per year, medium shear strength, and a high resistance to piping. This soil type also has a high resistance to erosion under low velocity flow;

however, excessive erosion can occur during the high velocity flows that can be expected when the dam is overtopped.

d. Appurtenant Structures

(1) Spillway

The inlet of the spillway has a good vegetative covering up to the control section with the exception of some minor erosion of the side slopes due to wave action (see Photo 6). The weathered bedrock lining of the discharge channel is eroding; however, the erosion did not appear to have any effect on the stability of the spillway. Additional erosion was seen along the toe of the dam caused by flow in the discharge channel.

The inlet and control section of the spillway were unobstructed and should function as intended (see Photo 7); however, numerous small trees were growing in the discharge channel (see Photo 8). The trees enhance turbulence in spillway discharges, which would increase the probability of further erosion in the channel and along the toe of the dam.

The triangular shape of the control section is not the most desirable configuration for an earth-lined spillway channel. When the spillway is operating, the wetted perimeter of the section is comprised of only the side slopes. On the side slopes, the tractive force of the flowing water is coupled with gravitational force increasing the instability of the slope and the likelihood of erosion. With a comparably sized trapezoidal channel, the wetted perimeter has also a horizontal component, thus reducing the contribution of the side slope components. The horizontal portion is subject to only the tractive force of the flowing water. Therefore, by reducing the side slope contribution to the wetted perimeter, a trapezoidal channel would be more stable. Nevertheless, the triangular shape of the control section has caused no discernible damage to the spillway channel or the safe operation of the spillway.

(2) Outlet Works

No low-level outlet or outlet works were provided for this dam.

e. Reservoir Area

The reservoir water surface elevation at the time of the inspection was 794.4 feet above M.S.L. The reservoir has a normal water surface elevation of 796.1 feet above M.S.L. and a surface area of seven acres at the normal water surface level.

The rim appeared to be stable with no erosional or stability problems observed, except for minor wave erosion (see Photo 9). The land around the reservoir slopes gently to moderately upward from the reservoir and is mostly covered with grass. Several homes are built around the reservoir rim. No evidence of excessive siltation was observed in the reservoir on the day of the inspection.

f. Downstream Channel

The downstream channel near the dam is the natural streambed. The channel is not well defined and partially obstructed with trees and bushes (see Photo 11). The spillway discharge channel intersects the downstream channel just downstream of the toe of the dam near the maximum section.

3.2 Evaluation

The visual inspection uncovered nothing of a consequential nature which would require immediate remedial action. However, the following conditions were observed which could adversely affect the dam in the future.

1. The erosion on the sides of the spillway inlet does not appear to constitute a hazard to the dam at this time. However, continued erosion could contribute to the instability of the dam in the future.

2. The erosion of the embankment caused by discharge through the spillway does not appear to affect the stability of the dam at this time; however, this condition will worsen with future flows. The meandering alignment of the channel in the proximity of the embankment coupled with the presence of trees in the channel create an erosive hazard to the dam.

3. The wave erosion on the upstream slope does not appear to affect the stability of the dam in its present condition. However, continual erosion of the slope can only be detrimental to the structural integrity of the dam.

4. The trees growing on the embankment, especially on the downstream slope, can pose a potential danger to the safety of the dam depending upon the extent of their root systems. The root system of large trees present possible paths for piping through the embankment and can also do damage to the embankment by being uprooted during a storm.

5. The animal burrows observed on the downstream slope could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Kinnippi Lake Dam is used to impound water for recreational use. There are no specific procedures that are followed for the operation of this dam. The water level below the spillway crest is allowed to remain as full as possible.

4.2 Maintenance of Dam

Each property owner in the Kinnippi Lake subdivision pays an assessment for maintenance of the lake and dam property. The grass on the embankment is periodically mowed. Brush and saplings are periodically removed from the spillway discharge channel. Nevertheless, several trees were observed in the discharge channel and also on the embankment.

4.3 Maintenance of Operating Facilities

There are no operating facilities associated with this dam.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any warning system in effect for the dam, such as an electrical warning system or a manual notification plan.

4.5 Evaluation

Kinnippi Lake Dam does not appear to be neglected. The maintenance at the dam appears to be good; however, the remedial measures described in Section 7 should be undertaken to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

No hydrologic and hydraulic design data are available for Kinnippi Lake Dam. The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were prepared from field notes and sketches prepared during the field inspection. The reservoir elevation-area data were based on the U.S.G.S. Fletcher, Missouri Quadrangle topographic map (Advance Print, 7.5 minute series). The spillway and overtop release rates and the reservoir elevation-area data are presented in Appendix B.

The hydrologic soil group of the watershed was determined from information available in the U.S.D.A. Soil Conservation Service publication "Missouri General Soil Map and Soil Association Descriptions", 1979. The Probable Maximum Precipitation (PMP) used to determine the Probable Maximum Flood (PMF) was determined by using the U.S. Weather Bureau publication "Hydrometeorological Report No. 33" (April 1956). The 100-year and the 10-year floods were derived from the 100-year rainfall and the 10-year rainfall, respectively, of Sullivan, Missouri.

b. Experience Data

Records of reservoir stage or spillway discharge are not maintained for this site. However, according to Mrs. Hubbard, the maximum reservoir level was approximately 12 inches above the crest of the spillway.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

Both the Probable Maximum Flood and one-half of the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam. The peak inflows of the PMF and one-half of the PMF are 1,870 cfs and 935 cfs, respectively. The peak outflow discharges for the PMF and one-half of the PMF are 1,683 cfs and 657 cfs, respectively. The maximum capacity of the spillway just before overtopping the dam is 279 cfs. The PMF overtopped the dam by 1.17 feet and one-half of the PMF overtopped the dam by 0.56 feet. The total duration of flow over the dam is 3.33 hours during the occurrence of the PMF and 45 minutes during one-half of the PMF. The spillway/reservoir system of Kinnippi Lake Dam is capable of accommodating a flood equal to approximately 35 percent of the PMF just before overtopping the dam and will also accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The surface soils on the embankment and in the spillway consists of a silty clay. The spillway and the top and downstream slope of the dam have a good cover of grass. Nevertheless, the dam will be overtopped by over one-half of a foot during the occurrence of the one-half PMF which can cause severe erosion to the embankment due to the high velocity of flow on its downstream slope and could lead to the eventual failure of the dam. The maximum velocity of flow in the spillway during the one-half PMF will be about 7.5 ft/sec, which could also cause excessive erosion in the spillway channel due to the high velocity of flow.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately four miles downstream of the dam. Located within the damage zone are at least two dwellings, two trailers, one sewage lagoon, two buildings, one lake and dam (Mo. 30408),and two road crossings.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment or foundation during the visual inspection. The stability of the dam does not appear to be in jeopardy at this time; however, continual deterioration of the dam due to neglect and improper maintenance procedures can only endanger the structural integrity and safety of the dam. The wave erosion on the upstream slope does not appear to endanger the structural stability of the embankment in its present condition; however, continual erosion of the slope could be detrimental to the embankment. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

The inlet and control section of the spillway appear stable. However, discharges through the spillway have eroded a portion of the downstream embankment slope. Presently this erosion does not appear to create an unstable condition but will worsen with time. The upper portion of the spillway is unobstructed and appeared to be able to function properly.

b. Design and Construction Data

No design computations pertaining to the embankment were uncovered during the report preparation phase. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters were available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction were available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam or the spillway. The water level on the day of inspection was 1.7 feet below the crest of the spillway; however, the reservoir remains close to full most of the time.

d. Post Construction Changes

No post construction changes to the embankent are known to exist that will affect the structural stability of the dam.

e. Seismic Stability

The dam is located in Seismic Zone 2, as defined in the "Recommended Guidelines for Safety Inspection of Dams" as prepared by the Corps of Engineers (see Plate 9). Seismic Zone 2 is characterized by a moderate earthquake hazard. An earthquake of the magnitude that would be expected in Seismic Zone 2 should not cause significant distress to a well designed and constructed earth dam. Available literature indicates that no active faults exist near the vicinity of the damsite. The maximum recorded historic magnitude earthquake in the immediate vicinity of the damsite was the January 24, 1902, event of magnitude 5 located at a distance of 36 miles northeast of the damsite. This event cannot be correlated with known tectonic structure and is considered to probably be related to the release of accummulated residual strain along a buried pre-Quaternary fault. The attenuation of this event to the damsite would produce a peak ground acceleration of less than 0.05g which would not produce a significant seismic impact on the dam.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and the visual inspection. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of the inspection along with data available to the inspection team.

It is also important to realize that the condition of a dam depends upon numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Kinnippi Lake Dam is found to be "Inadequate". The spillway/reservoir system will accommodate about 35 percent of the PMF without overtopping the dam. If the dam is overtopped, the safety of the embankment would be in jeopardy due to the susceptibility of the embankment materials to erosion. High velocity of flow on the downstream slope of the dam could cause excessive erosion and eventually lead to a failure of the dam. The spillway system could also receive considerable damage during the occurrence of a severe flood.

The overall condition of the dam and spillway appears to be good; however, some items of concern were noted which will require attention. A quantitative evaluation of the safety of the embankment could not be made in view of the absence of seepage and stability analyses. The present embankment and spillway, however, appear to have performed satisfactorily since their construction without any major failure or evidence of instability. The dam has never been overtopped, according to Mrs. Hubbard, and no evidence indicating the contrary was observed. The safety of the dam can only be improved if the deficiencies described in Sections 3.2 and 6.1a are properly corrected as described in Section 7.2b.

b. Adequacy of Information

The conclusions presented in this report are based upon field measurements, past performance and the present condition of the dam. Information on the design hydrology, hydraulic design, operation, and maintenance of the dam was not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency

The items recommended in paragraph 7.2a should be pursued on a high priority basis. The remedial measures recommended in Paragraph 7.2b should be accomplished within a reasonable period of time.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several options that may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Increase the spillway capacity to pass one-half of the PMF, without overtopping the dam. The spillway should also be protected to prevent excessive erosion during the occurrence of one-half of the PMF.

2. Increase the height of the dam in order to pass one-half of the PMF without overtopping the dam; an investigation should also include studying the effects that increasing the height of the dam would have on the structural stability of the present embankment. The overtopping depth during the occurrence of one-half of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of the dam.

3. A combination of 1 and 2 above.

b. O & M Procedures

1. The banks of the spillway inlet should be stabilized and protected from future damage.

2. The erosion along the toe of the embankment adjacent to the spillway discharge channel should be repaired and stabilized. The alignment of the spillway discharge channel should be straightened in a direction away from the embankment.

3. The trees growing in the discharge channel and on the banks of the spillway should be removed and regrowth prevented. The grass lining of the spillway should also be mowed periodically.

4. The erosion due to wave action on the upstream slope should be properly repaired and the slope adequately protected from further damage.

5. All of the trees on the embankment should be removed and regrowth prevented. Removal of large trees should be under the guidance of an engineer experienced in the design and construction of earthen dams. Indiscriminate clearing could jeopardize the safety of the dam.

6. All burrowing animals should be eliminated from the embankment and their burrows properly backfilled and compacted.

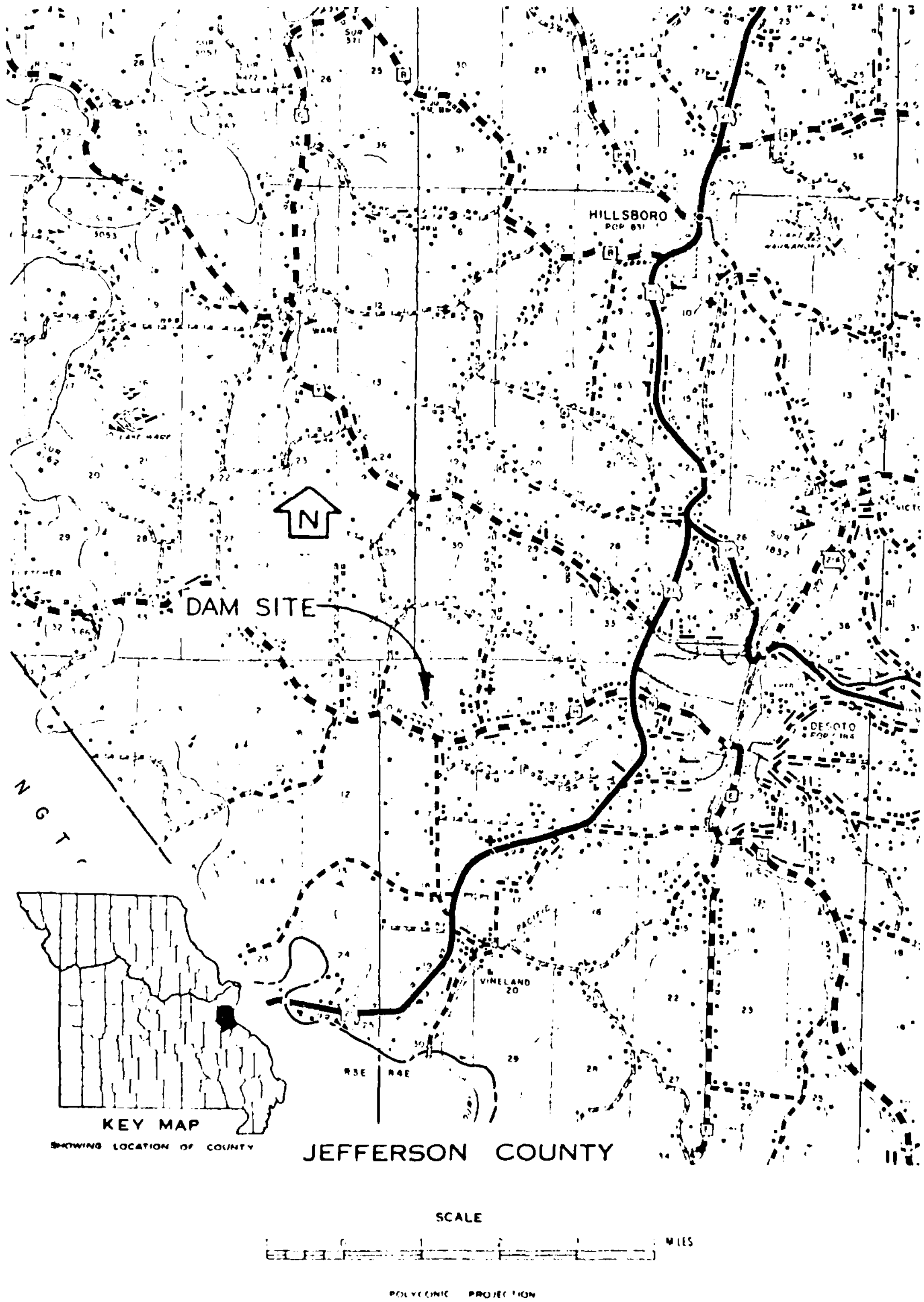
7. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.

8. The owner should initiate the following programs:

   (a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earth dams.

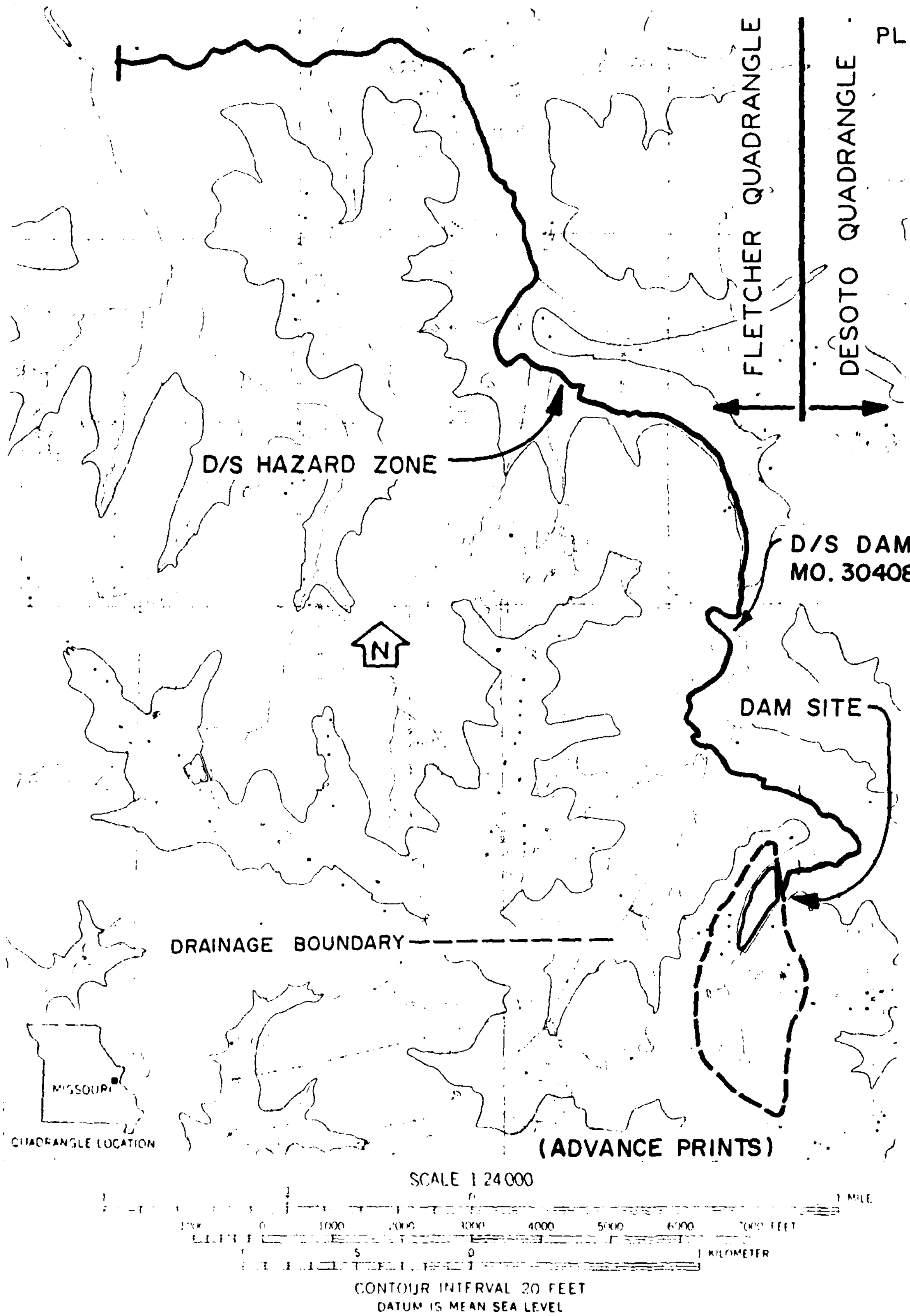
   (b) Set up a maintenance schedule and log all repairs, and maintenance.

PLATES



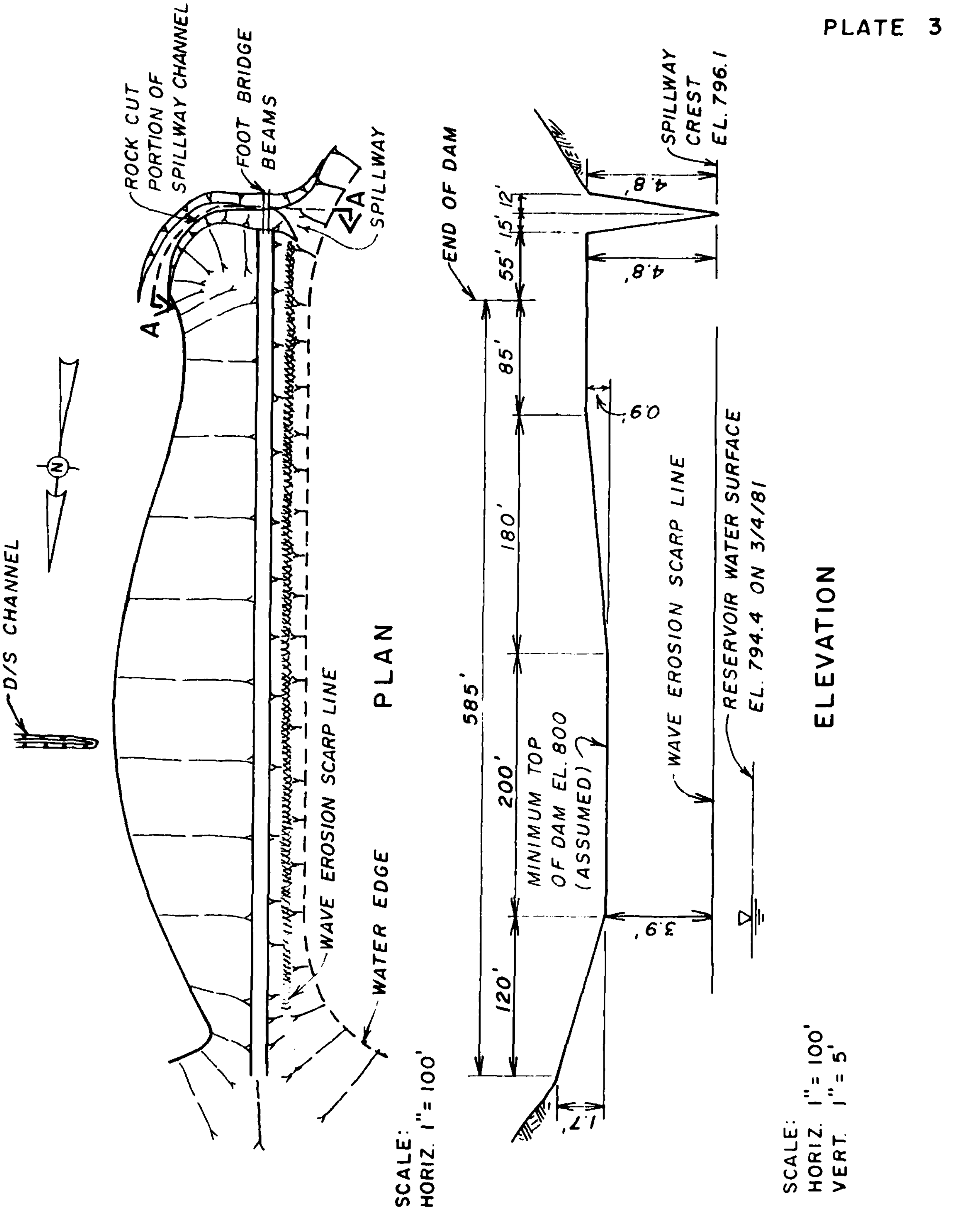
LOCATION MAP – KINNIPPI LAKE DAM

MO. 30406

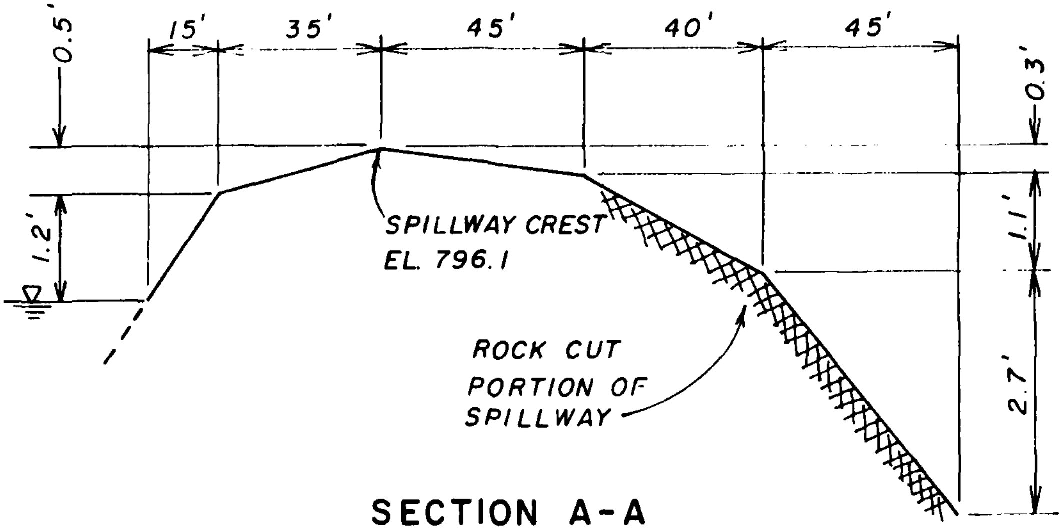


KINNIPPI LAKE DAM (MO. 30406)

DRAINAGE BASIN AND
DOWNSTREAM HAZARD ZONE

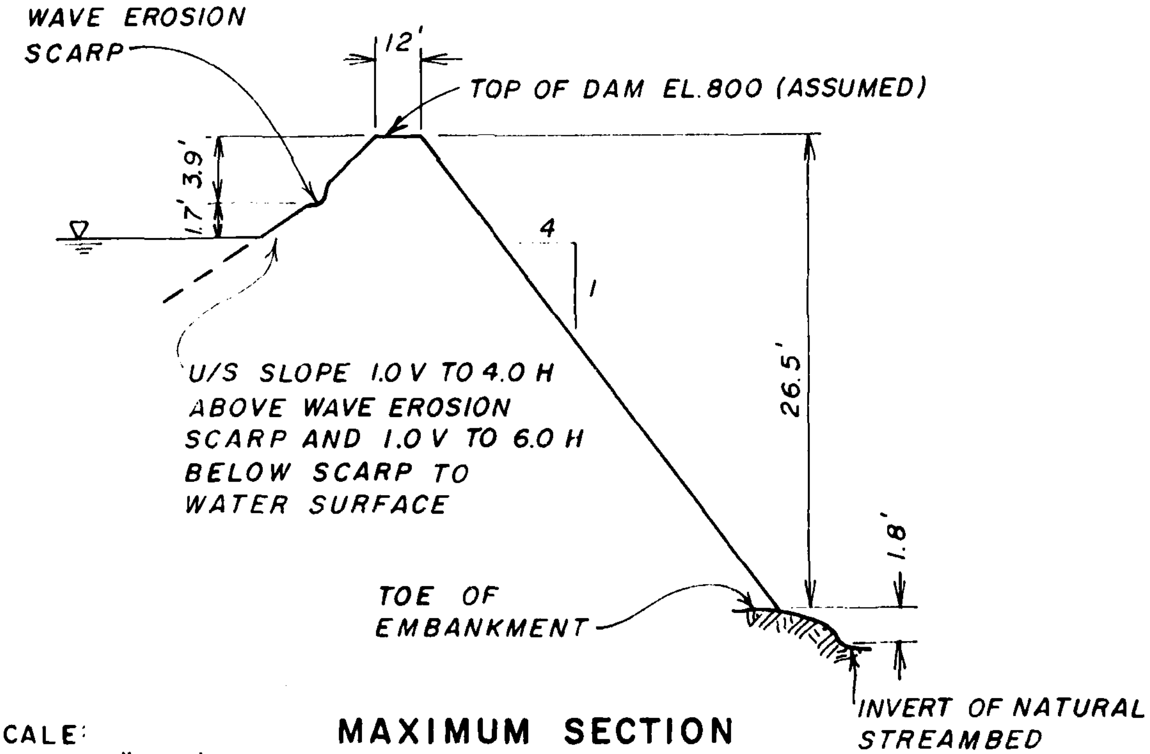


KINNIPPI LAKE DAM (MO. 30406)
PLAN AND ELEVATION
(SHEET 1 OF 2)



SECTION A-A
(SPILLWAY PROFILE)

SCALE:
HORIZ. 1" = 40'
VERT. 1" = 2'

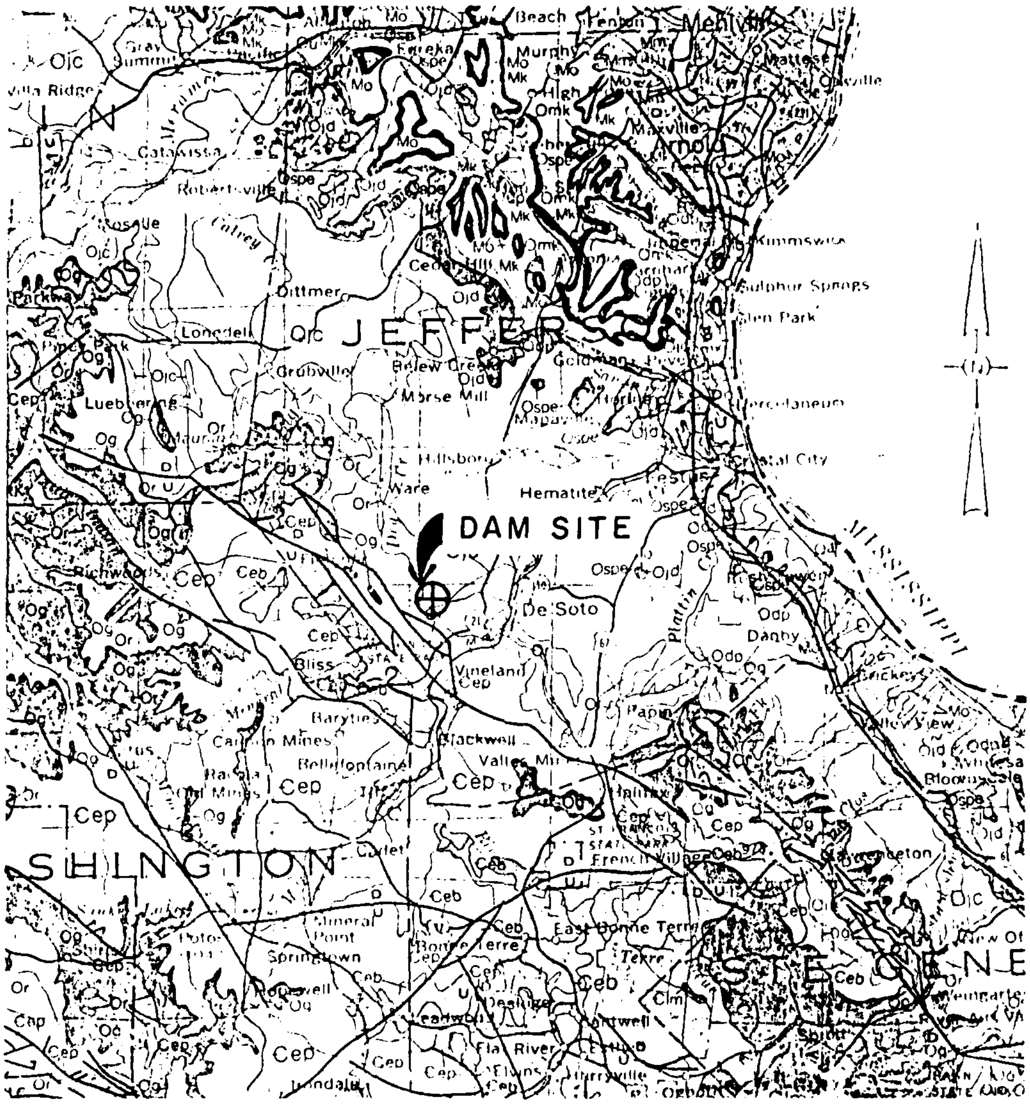


MAXIMUM SECTION

SCALE:
HORIZ. 1" = 40'
VERT. 1" = 10'

KINNIPPI LAKE DAM (MO. 30406)
SPILLWAY PROFILE AND MAXIMUM SECTION
(SHEET 2 OF 2)

PLATE 5



SCALE

10 0 10 20 30 40 Miles

⊕ LOCATION OF DAM

NOTE: LEGEND FOR THIS MAP IS ON PLATES 6 THROUGH 8.

REFERENCE:

GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP OF KINNIPPI LAKE DAM

LEGEND

PERIOD	SYMBOL	DESCRIPTION
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
MISSISSIPPIAN	Mm	ST. LOUIS FORMATION: LIMESTONE INTERBEDDED WITH SHALE
	Mm	SALEM FORMATION: LIMESTONE INTERBEDDED WITH SHALE AND SILTSTONE
	Mo	KEOKUK- BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	UNDIFFERENTIATED CHOUTEAU GROUP: LIMESTONE
	Mk	HANNIBAL FORMATION: SHALE AND SILTSTONE

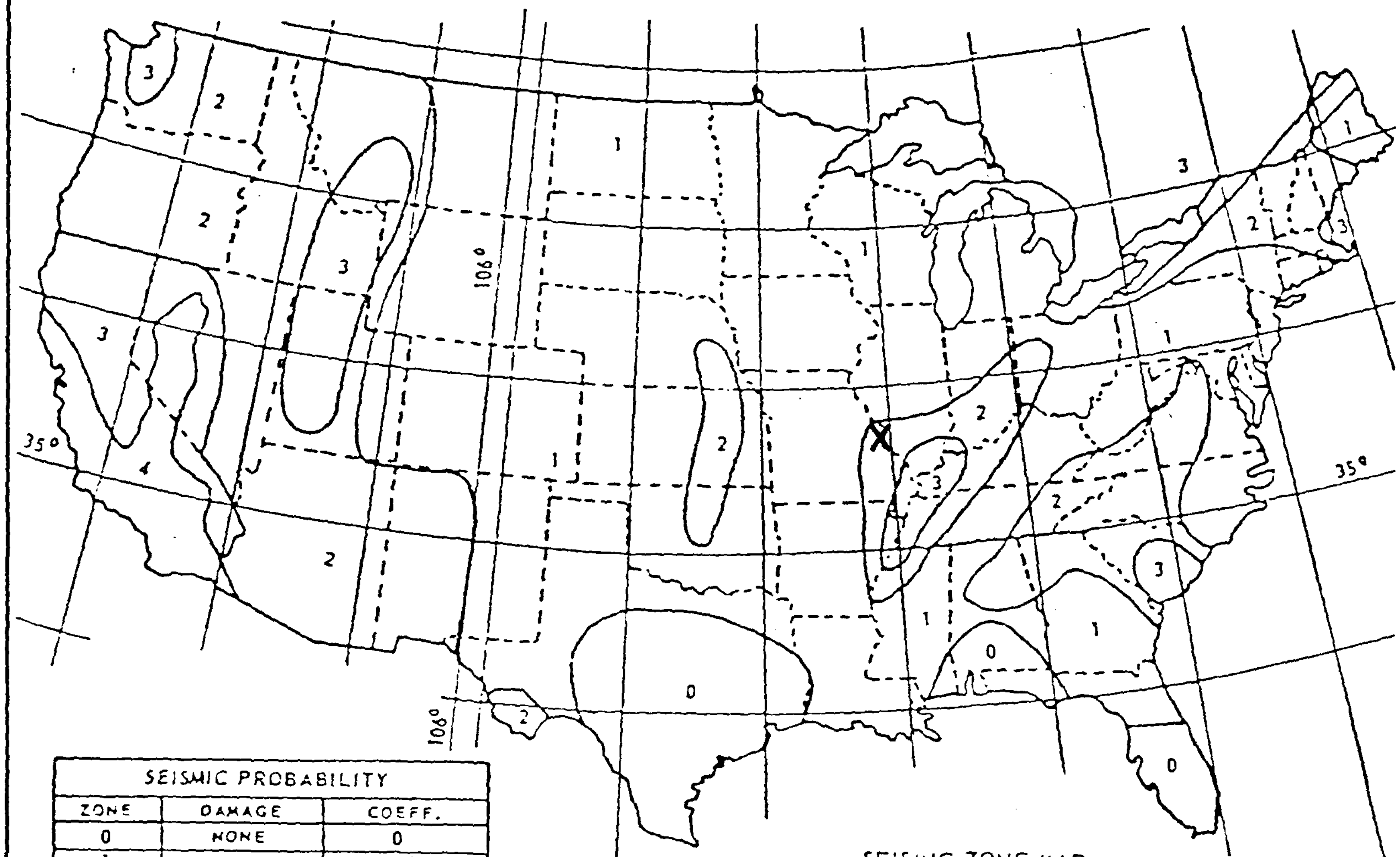
LEGEND

PERIOD	SYMBOL	DESCRIPTION
ORDOVICIAN	Ou	NOIX LIMESTONE
	Omk	MAQUOKETA SHALE, KIMMSWICK LIMESTONE
	Odp	DECORAH FORMATION: GREEN TO GRAY CALCAREOUS SHALE WITH THIN FOSSILIFEROUS LIMESTONE
	Ospe	ST. PETER SANDSTONE, EVERTON FORMATION
	Ojd	JOACHIM DOLOMITE
	Ojc	POWELL DOLOMITE, COTTER DOLOMITE
	Or	ROUBIDOUX FORMATION: INTERBEDS OF CHERTY LIMESTONE AND SANDSTONE
	Og	GASCONADE DOLOMITE

KINNIPPI LAKE DAM
PLATE 8
SHEET 3 OF 3

LEGEND

PERIOD	SYMBOL	DESCRIPTION
CAMBRIAN	€ep	EMINENCE DOLOMITE, POTOSI DOLOMITE
	€eb	FRANCONIA AND BONNETERRE FORMATION: INTERBEDDED LIMESTONE, CHERTY LIMESTONE, DOLOMITE AND SILTSTONE
	€lm	LAMOTTE SANDSTONE
PRECAMBRIAN	i	ST. FRANCOIS MOUNTAINS INTRUSIVE
	v	ST. FRANCOIS MOUNTAINS VOLCANIC
	U D	NORMAL FAULT
	U D	INFERRED FAULT
	U =	UPTHROWN SIDE ; D = DOWNTHROWN SIDE



SEISMIC ZONE MAP
of
CONTIGUOUS STATES

SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

X APPROXIMATE LOCATION OF KINNIPPI LAKE DAM

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

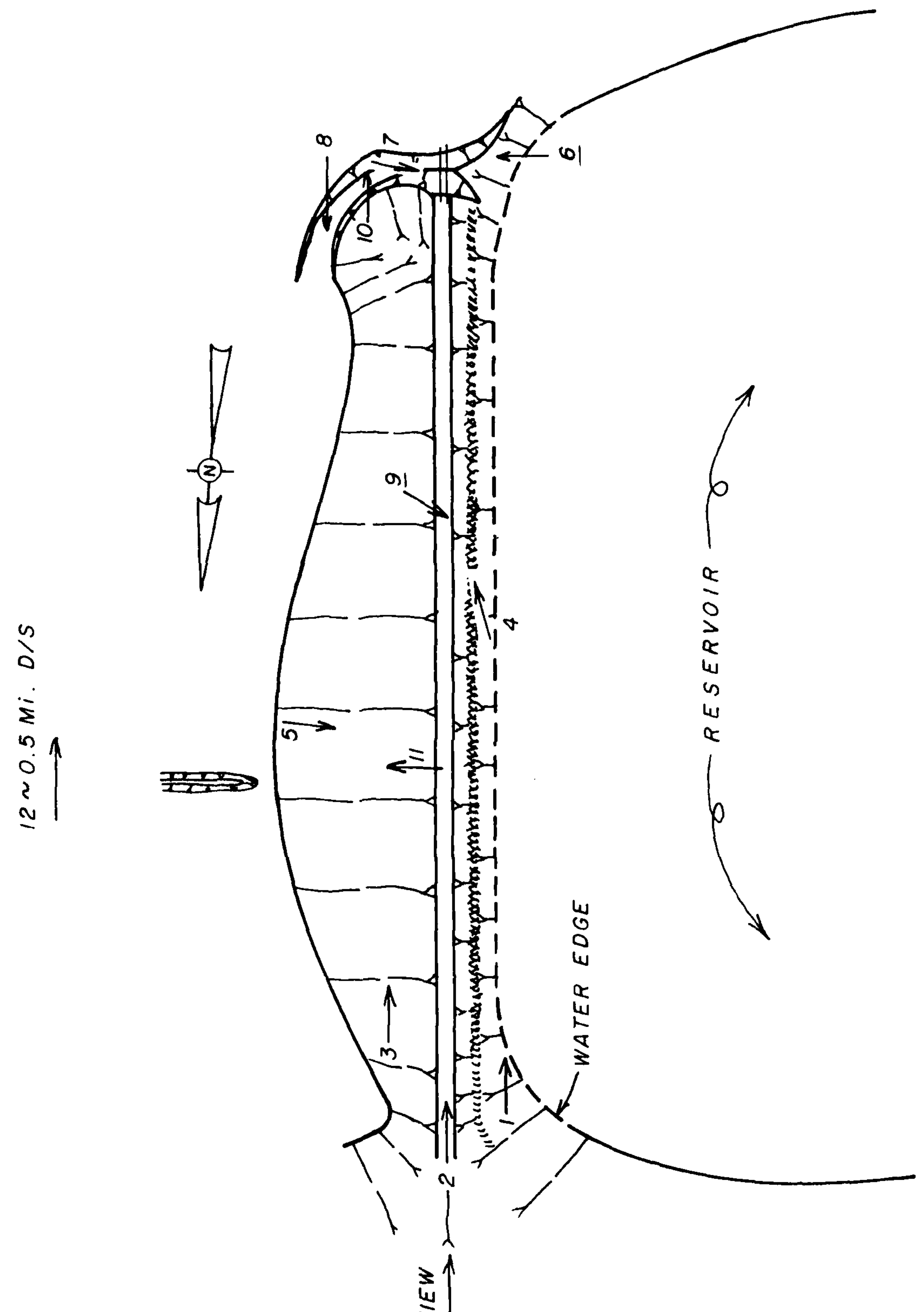


PHOTO INDEX
FOR
KINNIPPI LAKE DAM

Photo 1 - View of the upstream slope from the left abutment.

Photo 2 - View of the top of dam from the left abutment with the spillway in the background.

Photo 3 - View of the downstream slope from the left abutment.

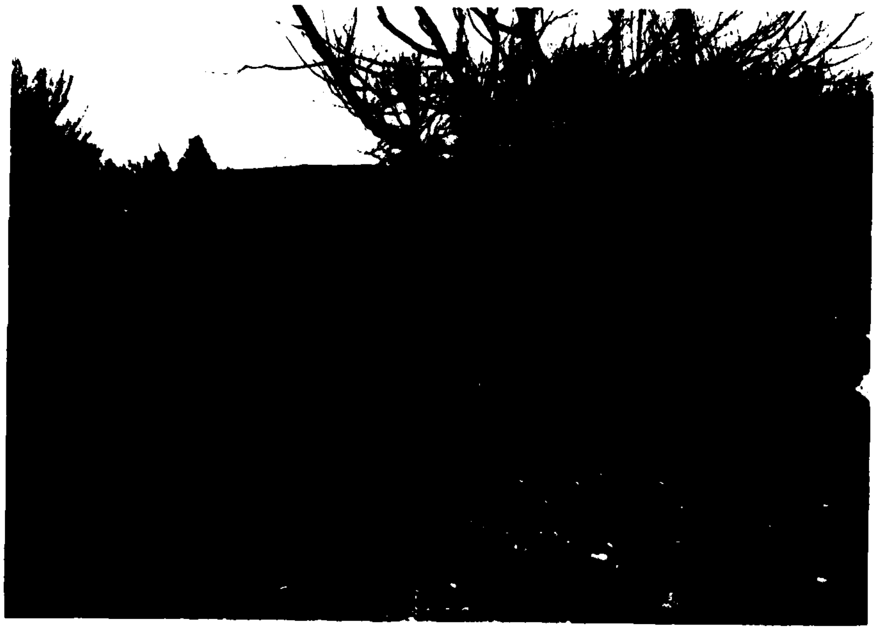


Photo 4 - Close-up view of wave erosion and tree growth on the upstream slope.

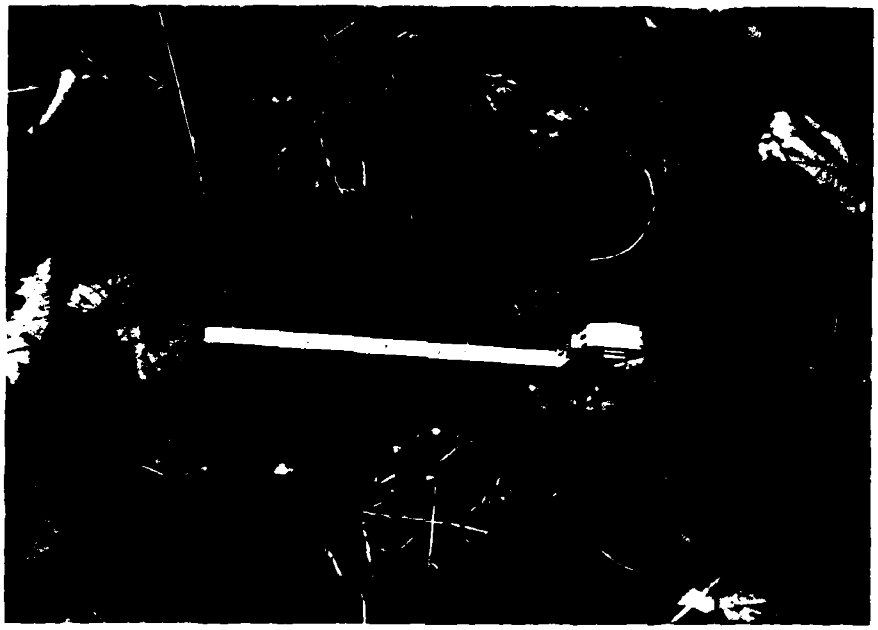


Photo 5 - Close-up view of rodent burrow on downstream embankment slope.

Photo 6 - View of the spillway inlet and eroded banks, with the foot-bridge remnants in the background.

Photo 7 - View of the spillway control section under the footbridge remnants, looking toward the reservoir.

Photo 8 - View of the spillway discharge channel looking downstream.

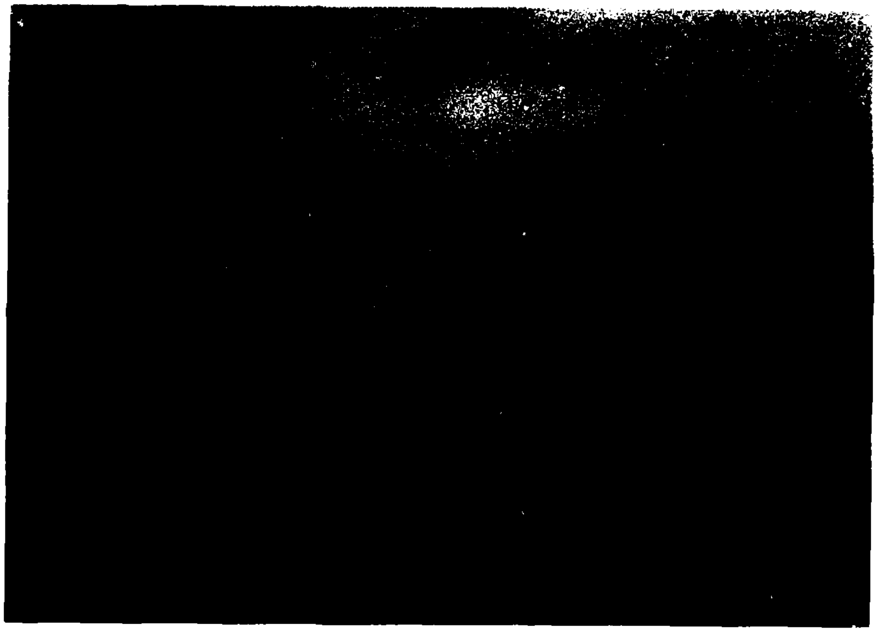


Photo 9 - View of the reservoir and rim.

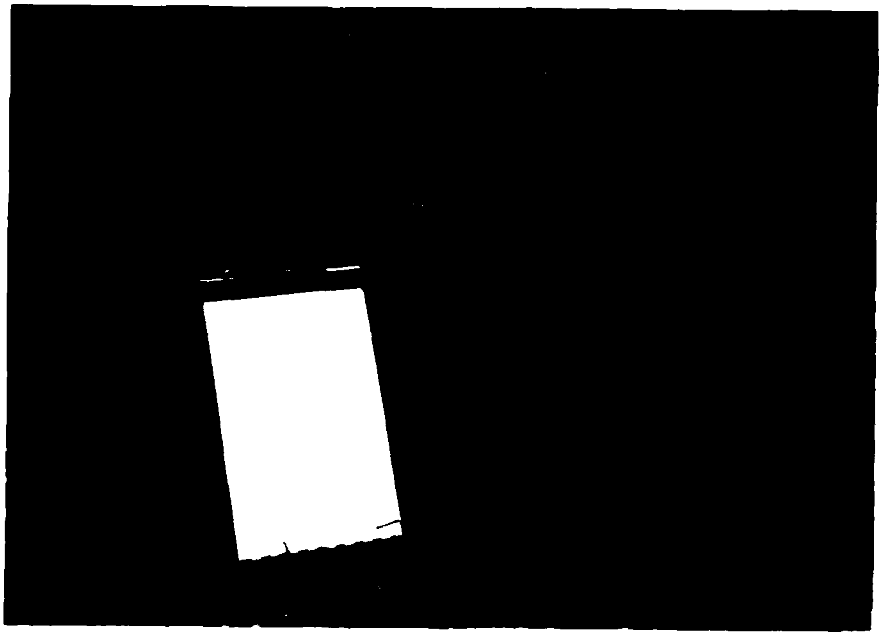


Photo 10 - View of outcropping of thinly bedded dolomite on the right bank of the spillway discharge channel.

Photo 11 - View of the downstream channel from the top of the dam.

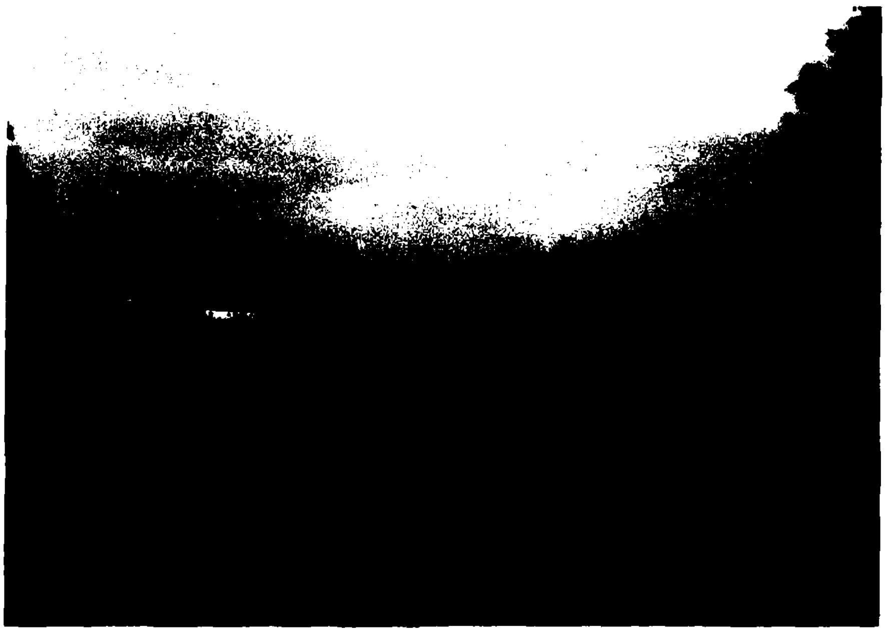


Photo 12 - View of two trailers in the downstream hazard zone with Dry Creek in the background.

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

KINNIPPI LAKE DAM

HYDROLOGIC AND HYDRAULIC DATA, ASSUMPTIONS AND METHODOLOGY

1. SCS Unit Hydrograph procedures and the HEC-1DB computer program are used to develop the inflow hydrographs. The hydrologic inputs are as follows:

   (a) 24-hour Probable Maximum Precipitation from Hydrometeorological Report No. 33, 24-hour 100-year rainfall and 24-hour 10-year rainfall of Sullivan, Missouri.

   (b) Drainage area = 0.14 square miles.

   (c) Lag time = 0.13 hours.

   (d) Hydrologic Soil Group:
   Soil Group "C".

   (e) Runoff curve number:
   CN = 71 for AMC II and CN = 86 for AMC III.

2. Flow rates through the spillway were determined by assuming critical depth. Flow rates over the dam are based on the broad-crested weir equation $Q = CLH^{3/2}$ and critical depth assumption, in accordance with the procedures used in the HEC-1 computer program.

3. The spillway and the dam overtop rating curves are hand calculated and combined as shown on pages B-4 and B-5. This combined rating curve is input into HEC-1DB on the Y4 and Y5 cards. The $L and $V cards are, therefore, not used.

4. Floods are routed through Kinnippi Lake to determine the capability of the spillway.

EC-4 **PRC ENGINEERING CONSULTANTS, INC.**

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. ___ OF ___

DAM NAME: Kimmille Lake Dam (MO 30406) — JOB NO. 1283

UNIT HYDROGRAPH PARAMETERS — BY TP DATE 3/26/81

1) DRAINAGE AREA, $A = 0.14$ sq. mi = (87.2 acres)

2) LENGTH OF STREAM, $L = (1.4'' \times 2000' = 2800') = 0.53$ mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$$H_1 = 891$$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 796.1$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 880$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 810$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = 0.033$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = 0.22 \text{ hr.}$$

B) BY VELOCITY ESTIMATE,

SLOPE = 3.3% $\Longrightarrow$ AVG. VELOCITY = 3 ft/sec.

$$t_c = L/V = \frac{2800'}{3'/\text{sec} * 3600 \text{ sec/hr}} = 0.26 \text{ hr.}$$

USE $t_c = 0.22$ hr.

9) LAG TIME, $t_\ell = 0.6\, t_c = 0.13$ hr.

10) UNIT DURATION, $D \leq t_\ell / 3 = 0.043$ hr. < 0.083 hr.

USE $D = 0.083$

11) TIME TO PEAK, $T_P = D/2 + t_\ell = 0.17$ hr.

12) PEAK DISCHARGE,

$$q_P = (484 \times A)/T_P = \frac{(484 * 0.14)}{0.17} = 399 \text{ c/s}$$

PRC ENGINEERING CONSULTANTS, INC.

Missouri Dam Safety

Kinnippi Lake Dam (MO. 30406) 1283

Reservoir Elevation : Surface Area data TP 3/26/

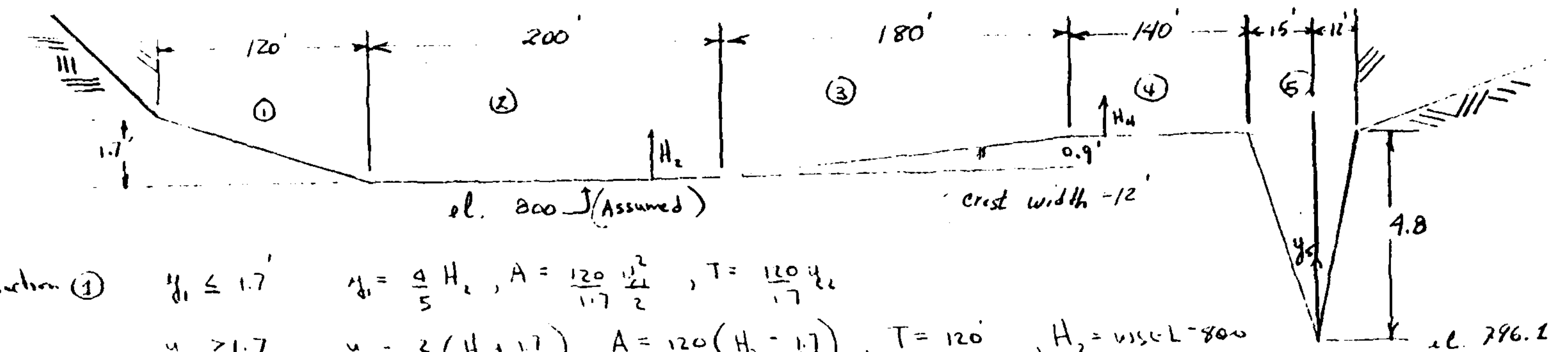
Reservoir Elev. (NGVD)	Surface Area	Remarks
775.0	0.0	Assumed stream bed el.
785.0	3.0	Interpolated
796.1	7.0	Spillway crest
800.0	10.0	Minimum top of dam (Assumed)
810.0	17.5	Interpolated
820.0	25.0	Measured on Fitzler, MO 7.5' Quad

PRC ENGINEERING CONSULTANTS, INC.

Dam Safety Inspection

Kinnippi Lake Dam (MO. 30406) 1283

Spillway and overtop rating curve TP 3/26/81



Section ① $y_1 \le 1.7'$ $y_{c1} = \frac{4}{5} H_2$, $A = \frac{120}{1.7} \frac{y_{c1}^2}{2}$, $T = \frac{120}{1.7} y_{c1}$

$y_{c1} > 1.7$ $y_{c1} = \frac{2}{3}\left(H_2 + \frac{1.7}{4}\right)$, $A = 120\left(H_2 - \frac{1.7}{2}\right)$, $T = 120'$, $H_2 = WSEL - 800$

Section ② for all depths $Q = CLH_2^{3/2}$, $H_2 = WSEL - 800$

Section ③ $y_{c3} \le 0.9$ $y_{c3} = \frac{4}{5} H_2$, $A = \frac{180}{0.9} \frac{y_{c3}^2}{2}$, $T = \frac{180}{0.9} y_{c3}$

$y_{c3} > 0.9$ $y_{c3} = \frac{2}{3}\left(H_2 + \frac{0.9}{4}\right)$, $A = 180\left(y_{c3} - \frac{0.9}{2}\right)$, $T = 180$

Section ④ for all depths $Q = CLH_4^{3/2}$, $H_4 = WSEL - 800.9$

Section ⑤ $y_{c5} \le 4.8$ $A = y_{c5}\left(y_{c5} * \frac{m_1 + m_2}{2}\right)$ $m_1 = \frac{15}{4.8}$, $m_2 = \frac{12}{4.8}$, $T = 2y_{c5}\left(\frac{m_1 + m_2}{2}\right)$

$y_{c5} > 4.8$ $A = \left(64.8 + (y_5 - 4.8)T\right) \Longrightarrow T = 15 + 12 = 27$, $V = \sqrt{g\frac{A}{T}}$, $Q = VA$

$WSEL = 796.1 + y_5 + v_5^2/2g$

PRC ENGINEERING CONSULTANTS, INC.

Dam Safety Inspection — SHEET NO. ___ OF ___

Kinmiller Lake Dam (MO. 30406) — JOB NO. 1283

Spillway and overtop rating curve — BY TP — DATE 3/26/81

Reservoir Elevation	y_1	A_1	T_1	V_1	Q_1	H_2	C_2	Q_2	y_{c3}	A_3	T_3	V_3	Q_3	H_4	C_4	Q_4	y_5	A_5	T_5	V_5	Q_5
797.2																	0.9	2.3	5.1	3.8	8.7
797.6																	1.2	4.1	6.8	4.4	17.8
798.1																	1.6	7.2	9.	5.1	36.5
798.5																	1.9	10.2	10.7	5.5	56.2
799.1																	2.4	16.2	13.5	6.2	100.7
799.7																	2.9	23.7	16.3	6.8	161.6
800.4	0.32	3.61	22.6	2.3	8.2	0.4	3.01	152.3	0.32	10.2	64.	2.3	34.6				3.4	32.5	19.1	7.4	240.5
801.0	0.8	22.6	56.5	3.6	81.1	1.0	3.03	606.	0.8	64.	160.	3.6	229.7	0.1	2.93	13.	3.9	42.3	21.9	7.9	334.
801.6	1.3	57.8	90.4	4.5	262.5	1.6	3.04	1230.5	1.2	138.	180.	5.0	685.7	0.7	3.03	57.4	4.4	54.5	24.8	8.4	458.3
802.3	1.8	116.	120.	5.6	647.2	2.3	3.07	2141.7	1.7	222.	180.	6.3	1399.	1.4	3.04	705.0	4.9	61.5	27.	9.0	605.6
803.0	2.3	172.	120.	6.8	1168.5	3.0	3.09	3211.2	2.2	306.	180.	7.4	2264	2.1	3.07	1308.	5.4	81.	27.	9.8	796.1
803.8	2.8	236.	120.	8.0	1878.	3.8	3.09	3356.8	2.7	402.	180.	8.5	3409.	2.9	3.09	2136.4	5.9	94.5	27.	10.6	1003
804.5	3.3	292.	120.	8.9	2584.7	4.5	3.09	5899.4	3.2	486.	180.	9.3	4531.5	3.6	3.09	2954.9	6.4	108	27	11.3	1225.7

Reservoir EL.	Q_T
796.1	0
797.2	9
797.6	18
798.1	37
798.5	56
799.1	101
799.7	162
800.4	436
801.0	1269
801.6	2694
802.3	5499
803.0	8748
803.8	11783
804.5	17196

PRC ENGINEERING CONSULTANTS, INC.

Dam Safety Inspection - Missouri SHEET NO ____ OF ____
Kiwanis Lake Dam (MO. 30406) JOB NO. 1283
Check Critical Depth Assumption in Spillway BY JFK DATE 4/29/81

$S_{lope\ channel} = 0.3/4.5 = 0.067$

$$Q_n = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

$$S = \left[\frac{Q_n}{1.49} \frac{1}{A} \frac{1}{R^{2/3}}\right]^2$$

for $Q = 100.7$
$y = 2.4$
$A = 16.2$
$R_h \cong 1.2$
$n = 0.025$

$$S_n = \left[100.7 \frac{(.025)}{1.49} \frac{1}{16.2} \frac{1}{(1.2)^{2/3}}\right]^2$$

$S_n = 0.0085 < S_{channel}$ ✓

∴ critical depth assumption is valid

SUMMARY OF PMF AND ONE-HALF PMF ROUTING

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***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
***********************************
     1            A1                MISSOURI DAM SAFETY
     2            A2             KINNIPPI LAKE DAM
     3            A3                  PMF AND 50 PERCENT PMF
     4            B    300       0       5       0       0       0       0       0       0       0
     5            B1     5
     6            J      1       2       1
     7            J1     1      .5
     8            K       DA KIPPI                                   1
     9            K1      RUNOFF CALCULATION FOR KINNIPPI LAKE DRAINAGE AREA
    10            M      1       2     .14             .14       1                       1
    11            P           25.7     100     120     130
    12            T                                                 -1     -86
    13            W2           .13
    14            X                      1
    15            K      1KIPPI DM                                   1
    16            K1      ROUTE HYDROGRAPH THROUGH KINNIPPI LAKE DAM
    17            Y                              1       1
    18            Y1     1                                      -796.1      -1
    19            Y4 796.1   797.2   797.6   798.1   798.5   799.1   799.7   800.4     801   801.6
    20            Y4 802.3     803   803.8   804.5
    21            Y5     0       9      18      37      56     101     162     436    1269    2694
    22            Y5 5499    8748   11783   17196
    23            $A     0       3       7      10    17.5      25
    24            $E   775     785   796.1     800     810     820
    25            $$ 796.1
    26            $D   800
    27            K     99
```

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	796.10	796.10	800.00
STORAGE	64.	64.	97.
OUTFLOW	0.	0.	279.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	801.17	1.17	109.	1683.	3.33	15.75	0.00
.59	800.56	.56	103.	657.	.75	15.83	0.00

PERCENT OF PMF ROUTING
EQUAL TO SPILLWAY CAPACITY

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
    1            A1                MISSOURI DAM SAFETY
    2            A2              KINNIPPI LAKE DAM
    3            A3        PERCENT PMF
    4            B      300      0      5      0      0      0      0      0     -4      0
    5            B1       5
    6            J        1      3      1
    7            J1      .3    .33    .35
    8            K         DA KIPPI                                  1
    9            K1        RUNOFF CALCULATION FOR KINNIPPI LAKE DRAINAGE AREA
   10            M        1      2    .14           .14      1                    1
   11            P             25.7    100    120    130
   12            T                                                  -1    -86
   13            W2              .13
   14            X                      1
   15            K        1KIPPI DM                                  1
   16            K1        ROUTE HYDROGRAPH THROUGH KINNIPPI LAKE DAM
   17            Y                             1      1
   18            Y1       1                                     -796.1     -1
   19            Y4   796.1  797.2  797.6  798.1  798.5  799.1  799.7  800.4    801  801.6
   20            Y4   802.3    803  803.8  804.5
   21            Y5       0      9     18     37     56    101    162    436   1269   2694
   22            Y5    5499   8748  11783  17196
   23            $A       0      3      7     10   17.5     25
   24            $E     775    785  796.1    800    810    820
   25            $$   796.1
   26            $D     800
   27            K       99
```

B-11

SUMMARY OF DAM SAFETY ANALYSIS

1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	796.10	796.10	800.00
STORAGE	64.	64.	97.
OUTFLOW	0.	0.	279.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.30	799.83	0.00	95.	214.	0.00	16.00	0.00
.33	799.98	0.00	97.	273.	0.00	15.92	0.00
.35	800.08	.08	98.	309.	.25	15.92	0.00